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SPRAYING

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SPRAYING.

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There are four fundamental principles upon which all methods for controlling plant diseases are based, namely, *exclusion*, *eradication*, *protection* and *immunization*.

It is upon the first of these, exclusion, that all quarantine and similar exclusionary methods and measures are based. The United States quarantine act of 1912, together with its numerous amendments, the rules based thereon and quarantines laid thereunder by the Federal Horticultural Board constitute the most extensive application of this principle ever undertaken. Upon the soundness of exclusion as a fundamental principle in disease control there can be no question; upon the practicability or advisability of its application for the exclusion of foreign pathogenes and pests from this country under modern conditions of commerce and transportation, there is abundant ground for honest difference of opinion which only trials and time can settle.

Eradication of pests and pathogenes which have become established in crop areas of larger or smaller extent has been applied in this country during the last decade on an extensive scale in a number of notable cases, as, for example, the chestnut blight, the white pine blister rust, the citrus canker, and several insect pests. Remarkable success is claimed in a number of these cases, while in others equally notable failure is admitted. The eradication of certain disease-inducing fungi, such as grain smut, the potato scab organism, etc., from limited areas has long been regarded a successful practice.

Protection of crops from the attacks of fungi and insects by the interposition of some sort of barrier is perhaps the oldest and most widely applied of these four principles of control. It is upon this principle that spraying is based. Spraying is, in most cases, a method of protection. It has been for nearly four decades the chief weapon of the fruit grower in combating the insects and fungi that attack his crops.

Immunization, the development of immune or highly resistant strains or varieties of cultivated crops, has but recently received the practical consideration which its promise of profitable application has warranted from the first. The perennial nature of the crops of the fruit grower makes its application to their problems of less immediate promise than in the case of the annual crops of the cereal or field crop farmer.

Our attention, therefore, to-day will be directed to a consideration of the principle of protection and more specifically to spraying as a method based upon this principle.

DEFINITION.

Spraying consists in the application of fungicides and insecticides in liquid form for the protection of our fruit crops. While, in general, spraying is to be looked upon as a method of protection, it is in a few cases a distinctly eradication method as, for example, in the case of the control of peach leaf curl or San José scale. We shall, however, confine ourselves to-day chiefly to its applications in the control of scab and codling moth of apples and the brown rot and curculio of the peach.

HISTORY.

A brief consideration of the history of spraying, particularly in the United States, will afford a desirable background for a better understanding of the practice as now in vogue in this country.

Spraying, as a measure for protection against pests and diseases of plants, may be said to have been introduced into the United States about 1885. Following the discovery of Bordeaux mixture by that noted Frenchman Millardet, in France in 1883, the mixture was almost immediately tried

out in this country for the black rot of grapes, the apple scab and the late blight of potatoes. The results were so satisfactory that within a decade it had become the generally recommended and accepted fungicide for most of the fungous diseases of our crops. It continued to hold this pre-eminent position until about 1906, when, through a discovery by Cordley in Oregon, lime-sulfur was introduced as a substitute for Bordeaux in the summer spraying of apples. The work of Wallace in New York during the years 1909 to 1912 on the control of apple scab by the use of lime-sulfur brought about the all but complete abandonment of Bordeaux as a fungicide for apple scab in that State. Work in the other apple-growing sections of northeastern United States, Canada and the Pacific Coast completely confirmed the results obtained in New York, so that within five years lime-sulfur had largely replaced Bordeaux as a summer spray for apples in most apple-growing regions in the United States and Canada.

It is interesting to observe in passing that experimental work on spraying as a field practice in the control of plant diseases and pests in this country was at first almost entirely in the hands of horticulturists. The reasons for this are not far to seek. Plant pathologists as such were few and their efforts were largely confined to investigational work in the laboratory. They were busy with studies on the nature and life history of the organisms that caused these diseases. Horticulturists were far more numerous and were, from the nature of their work, most closely associated with the grower in the practical problems in the orchards and fields. Disease and pest control was looked upon as a practical problem rather than a scientific one. Plant pathology as a profession had little or no standing, while horticulture was generally recognized as the most advanced and progressive of agricultural professions.

The decade from 1900 to 1910 saw the entrance of the practical plant pathologist into the agricultural field in this country. The first university chair of plant pathology was established in America in 1907. Before the end of the decade plant pathologists as such were appointed to positions in many of the agricultural colleges and experiment stations in this country. Immediately they began to claim their rightful place in agri-

cultural teaching and practice. They rapidly took from the horticulturist those functions and problems to which their professional training and obligations justly entitled them. The process of transferring the plant disease and insect pest work, especially their practical applications, from the horticulturist to the plant pathologist and entomologist is still going on. Another decade will see it completed. This division of labor and differentiation or specialization has had its usual reward in a phenomenal progress in disease and pest control. America, to-day, is twenty-five years in advance of Europe in the science and practice of plant disease control. The day of the professional plant doctor is at hand. Already the progressive farmers and fruit growers are bidding against the agricultural institution of the country for the services of the professional plant pathologists. They are buying their services with their own hard cash, and the institutions must look to their salaries if they expect to retain for State and Federal service the best men in the profession.

WHAT CONSTITUTES A GOOD FUNGICIDE.

A fungicide is a substance which properly and timely applied to susceptible parts of the living plant will protect it from the attacks of pathogenic organisms.

The requirements of a good fungicide are effectiveness against the pathogene to be controlled, safety to the plant to which applied and adhesiveness. As corollaries to these fundamental requirements are to be noted cheapness, ease of application, and miscibility with insecticides.

With the introduction and development of Bordeaux mixture, copper became the all but universal active agent in fungicides. Bordeaux meets the above requirements of an acceptable fungicide to a remarkable degree. Copper is probably the most active fungicidal agent yet discovered. Combined with calcium in the form of a colloid known as Bordeaux mixture, it possesses a degree of adhesiveness as yet unsurpassed. Its injurious action on the living tissues of many plants, especially apples, peaches, plums and cherries, has led, however, to a persistent search for substitutes. Among the substances pro-

posed from time to time to take the place of copper, none has been found to so generally meet the requirements as sulfur. Known and used as a fungicide long before the introduction of copper sulphate, it was almost entirely discarded upon the discovery of Bordeaux mixture. With the gradual appreciation of the injurious action of the copper in Bordeaux upon the fruit and foliage of the apple, and its early recognized unsafety on the leaves of stone fruits, came the demand for a safer substitute in the spraying of these fruits. With Cordley's discovery of the efficiency and safety of lime-sulfur as a substitute for Bordeaux on apples and Scott's development of the self-boiled lime-sulfur for peaches, the fallacy of a universal fungicide was at last definitely recognized. To-day, we accept the fact that both copper and sulfur have a distinct place in plant medicine, and other substances promise to find a place in plant prophylaxis.

RELATION OF FUNGICIDES TO INSECTICIDES.

In the development and applications of a fungicide, one of the chief problems which the pathologist has to meet is its combination with insecticides. Modern agricultural practice requires a rigid economy in operation. The cost of labor and the requirements of timeliness in application demand that in most cases fungicide and insecticide shall go on to the crop in the same operation.

Arsenic in some form continues to be the chief agent in the killing of chewing insects. Nothing has yet proved so effective as nicotine for contact killing of sucking bugs, such as aphids, red bug, psylla and the like. A practical fungicide must therefore be subject to safe and effective combination with insecticides in which both arsenic and nicotine in some form are to be used. Happily, both Bordeaux and lime-sulfur have qualified in this respect to a remarkable degree. Wallace has shown that the fungicidal value of lime-sulfur is even increased by combination with arsenate of lead, without any evident decrease in safety to either. Nicotine sulfate, sold under the trade name of Black Leaf 40, has likewise proved a safe and efficient contact insecticide in combination with both Bordeaux and lime-sulfur.

It is evident, therefore, that we have in our present standard fungicides and insecticides that fortunate compatibility so requisite for practical and efficient use in meeting the problems of disease and pest control.

MODERN SPRAYING MACHINERY.

While the discovery and development of safe and effective fungicides and insecticides have been fundamental to the present-day methods of plant protection, the perfection of machinery with which to apply them has been almost equally important. Bordeaux was first applied with a whisk broom, and the primitive sprayers of the 80's were scarcely more than sprinklers. We regard with amusement and contempt the so-called nozzles through which our fathers squirted Bordeaux and paris green. The knapsack and barrel hand-pump sprayer have been almost entirely replaced by the handy compressed-air sprayers and engine-driven orchard outfits. The mechanical genius of the manufacturers has given us an annual crop of improved nozzles, the most modern development of which is the spray gun. Once satisfied with a pressure of 25 to 50 pounds, we now demand 200 to 300 to get that fine driving mist so generally recognized as essential to effective application. The development of the spray gun was a direct reply to the demand for greater rapidity and conservation of labor in our spraying operations. Speed in operation has been obtained, however, at the sacrifice of certain essentials in application. A greatly increased wastage of spray materials has undoubtedly resulted where spray guns have replaced the pole and angle nozzle. Inferior control or distribution of material over the leaf surface, especially in large trees, unquestionably occurs, with the result that only the lower branches are thoroughly covered, while the attempt to reach the higher parts of the trees has resulted in frequent and serious foliage injury due to drenching of the leaves below. In spite of the claims that the solid stream from the gun will break into a fine mist in the tops of tall trees, an examination of the foliage there, and the poor control of scab and worms frequently to be observed on the higher branches, does not bear out these claims. If one is to judge from the frequent comment of gun

users during the past season, a general return to the slower but more efficient pole and nozzle equipment is setting in. There is no question that under certain conditions, for certain purposes, and in the hands of competent operators the gun has proved a rapid and efficient spraying weapon. But for general orchard spraying and in the hands of the unskilled labor at present available for the work, it is less satisfactory than the best angle nozzle at the end of a 10 to 14 foot pole. Had the tower and double lead of hose been retained, the advent of the spray gun would undoubtedly have proved much less of a disappointment.

TIMELY APPLICATION.

Probably no feature of successful spraying is less understood and appreciated by the average grower than timeliness of application. In spite of accumulating evidence and the persistent teaching of plant pathologists during the past ten years, growers have failed to fully appreciate or have not understood the absolute necessity of getting the spray mixtures on at just the right time. This factor more than any other conditions success or failure of spraying operations. "Spray just before the rains, not after" has been shouted at you from platform and printed page. The deeply rooted notion that rains will wash off the fungicide or poison has been completely disproved and exploded. It has been repeatedly shown that for any given successful application usually not to exceed two or three days are available. Yet in spite of the fact that every intelligent grower knows that not more than 4 acres of full-grown apple trees on the average can be properly sprayed in a day, almost none of you have a sufficient number of spray rigs available to cover your plantings in the period available for successful operation. There are still many growers who spray when most convenient, thereby often missing the most effective time for doing the work. A not inconsiderable number try to beat the game by spraying almost continuously throughout the season with the result that they waste most of their time, labor and materials. A few growers have begun to appreciate the absolute necessity for timeliness in application and have sought to meet the situation by doubling or trebling their equipment,

but the high cost of machinery and labor has made the expense of such measures increasingly prohibitive. Very recently growers have begun to look with hope to dusting as a means of meeting the situation, but for the great mass of our fruit growers a lack of understanding or appreciation of the factor of timeliness constitutes the chief cause of failure to control diseases and pests where spraying is carried out.

DUSTING TO REPLACE SPRAYING.

Of the many problems pressing us for further study and investigation, none is more urgent than that of dusting. Prior to the war we carried out in New York State an extensive series of investigations on the relative efficiency of dusting in comparison with spraying for the control of apple scab and codling moth. Our results showed dusting to be equally effective against these two pests. Experiments since that time in other apple-growing regions, notably Michigan, Illinois and Nova Scotia, have given results in general accord with the results we obtained. But dusting, as a general practice, has made slow progress, due to certain limitations which, however, promise early solution. Among the chief drawbacks to its general adoption by our fruit growers has been the lack of an effective contact dust for sucking insects, like aphids, psylla and red bug. Preliminary experiments, especially in California and Nova Scotia, promise an effective nicotine dust in the near future. Improvements in dusting machinery, cheapening of dusting materials, and a better understanding of the factors conditioning effective application are pressing for attention.

Replying to a questionnaire sent last November to duster owners in New York State, 73 replied that they had dusted apples last season. Of these, 49 reported as good or better control of scab by dusting than by spraying; 51 reported codling moth as well or better controlled; and 68 (over 93 per cent) report that they will dust apples again next season. Even larger percentages replied in favor of dusting peaches and cherries.

The results obtained this past season in Nova Scotia, both in the experimental plots and in commercial orchards, were so

uniformly successful with dusting that its substitution for spraying will undoubtedly take place there as fast as the growers can change machinery.

With the cost of spray materials and machinery almost uniformly high, it is significant that dusting materials promise to be generally cheaper this next season than they were last and the demand for dusting machinery threatens to exceed the possible supply.

Dusting has so many promising and profitable features, especially as a saver of valuable time and labor, that its general adoption cannot long be delayed. The principles upon which it is based are sound; there is no virtue, *per se*, in the application of fungicides in water if the same materials can be applied dry. Professor Sanders of Nova Scotia has developed a new copper-lime dust which gives every promise of efficiency equal to that of the same materials in the form of liquid Bordeaux, and Dr. Brittain of the same province is at work on a nicotine contact dust which in preliminary experiments has given great promise as a killer of the sucking insects. Dry sulfur and arsenate of lead have already proved quite as effective when applied dry as when used in the liquid form.

With the standard fungicides and insecticides all thus available in dry form, there remains only to perfect the methods for their application in order to eliminate entirely the water which now so seriously interferes with rapid and timely operation in the control of our orchard pests and diseases.

THE COUNTY SPRAY SERVICE.

Impressed with the paramount importance of timely application in the control of apple scab and other fruit diseases in our New York orchards, we undertook about three years ago the experiment of organizing and directing a so-called spray service in certain of our best fruit counties. Upon request of the Farm Bureau organization a man with good fundamental training in plant pathology and entomology is placed in the county as special field assistant, with headquarters at the Farm Bureau office. The county provides and maintains a Ford for his use. He is assigned to the county about April 1 and re-

mains until about October 1. His job is to work out in co-operation with the county agent a plan for advising and directing the spraying operation of such growers as make request for the service. The extension pathologist and extension entomologist of the college supervise and direct his work. A variety of schemes for notifying the growers have been tried out, but the relay telephone system handled through the Farm Bureau office has usually proved the most satisfactory and efficient. With one eye on the weather map and the other on the development of the buds, the field man determines the proper time for the most effective application and promptly notifies each grower a day or two in advance. The grower is also advised of the proper strength and combination of fungicides and insecticides to be used. A few criterion orchards, scattered at advantageous localities over the county, are sprayed under the personal supervision of the field assistant, and serve to demonstrate the efficiency of the recommendations sent out to the growers.

At first the State paid the entire salary of the field assistant and furnished supervision of his work without expense to the county. Last season six counties maintained such field assistants, providing one-third the man's salary. This coming season at least 8 counties will have a special field assistant on plant disease and insect control and will pay two-thirds the salary, the college providing but one-third. The growers receiving the service provide the funds for meeting the counties' share of the salary in addition to providing the funds for buying and maintaining the car. Besides general supervision by the extension pathologist and entomologist the college will provide (as it did last season) a special supervisor, who, during the growing season, will give all his time to assisting and overseeing the work of the special field assistant.

The positions of field assistant have been almost entirely filled by seniors or graduate students specializing in plant pathology and entomology. They are young men of marked ability but usually with little actual practical experience. That they have met their opportunities and responsibilities is evidenced in the rapidly increasing demand on the part of our growers for their services. The willingness of the growers to

bear an increasingly large proportion of the expenses of such service is a further indication of their confidence in this plan.

In emphasis of the justification and value of this service I can do no better than quote from a recent paper on the subject prepared by Professor C. R. Crosby, our extension entomologist, and G. R. Palmer, one of our most successful field assistants.

It is becoming increasingly apparent that to be most effective demonstration work in the control of insect pests and plant diseases should be conducted for the most part on the basis of a seasonal program of treatment and not by demonstrating the control of any single disease or pest nor by isolated tests of spray materials or methods of application. The object of this kind of demonstration work is to show the value of the approved seasonal program of treatment as adapted to local conditions and to the weather prevalent during the season, and to teach the growers the most effective and economical method of protecting their crops from insect pests and plant diseases. Both from an educational and financial standpoint demonstrations conducted in accordance with the seasonal program are of greater value not only to the individual but also to the county as a whole. Efficiency requires that the work be done with an organized group of growers rather than with individuals. In order to achieve this result it is necessary that sound expert advice be available and that the necessary information be placed in the hands of the growers at the time when it will be of most use to them.

The plan of doing this work by means of field assistants was adopted because our experiences with industrial fellowships financed by associations of farmers had shown that the greatest good can be accomplished in the control of insect pests and plant diseases by having a trained man located in a definite territory where he can become thoroughly acquainted with the local problems, can watch the crops throughout the growing season and by his intimate knowledge of conditions be able to anticipate and prevent destructive outbreaks. He also is able to win the respect and confidence of the farmers as they become familiar with his aims and methods of work. Our experiences have shown that, in general, graduate students, preferably the younger ones, are more efficient and successful in this line of work than are older persons who have become more or less settled in life and consequently opinionated. It has been generally supposed that for this kind of work mature men would be more desirable, but as a matter of fact such is not the case. Where we have been compelled to use older men not actively interested in science or where we have used graduate students who were past the optimum age for study, we have had more misfits and failures than where younger men with more active interest have been employed. This may seem paradoxical. The explanation is that the salary available is not sufficient to attract mature men of sufficient ability. It is much better for the work to employ young men of special ability in their ap-

prenticeship stage than men of mediocre ability who have nothing better in prospect. A young man who in the course of the next ten years is likely to be occupying a \$5,000 to \$10,000 position is much more valuable for this work than an older man who would be satisfied to take a short-term appointment at \$150 a month. The younger men look on this work as an opportunity to obtain first-hand knowledge of field conditions and methods and are therefore willing to spend the summer season for two or three years in this way since it is a part of their training and of direct advantage to them in their life work. Furthermore, they have an incentive to do their best, since if they make good as field assistants they have a better chance to obtain a good position on receiving the advanced degree; and, moreover, they do not receive a sufficient salary to make them wish to settle down in the work permanently as field assistants.

In western New York, particularly, where the control of apple scab is of the utmost importance, the weather is the vital factor in determining the time at which most sprays must be applied. In this region the work of the field assistants was greatly facilitated by the co-operation of the United States Weather Bureau. A special forecaster was detailed to the Rochester office from April 6 to July 10. Arrangements were made whereby he received from Washington twice daily a special long range forecast, covering the conditions most needed by the service. These forecasts were often modified by the special forecaster. At least one of these forecasts as modified by the forecaster was sent daily to each of the Farm Bureau offices where a special assistant was stationed. A striking illustration of the practical value of these forecasts occurred on May 12, when the forecast indicated that a rain was probable in three or four days. Scab infections had already occurred in considerable numbers in orchards that had not received the delayed dormant spray. A spray warning was issued calling for the application of the blossom pink spray immediately although the blossoms did not yet show pink. The rain began in the afternoon of May 16. Subsequent events showed that this was the critical application for the commercial control of apple scab in western New York this season. In orchards where the application was delayed until after the rain of May 16, 17, the leaves became badly infected with scab and a serious defoliation resulted. Furthermore, in these orchards it was very difficult to keep the fruit free from later infections. Had the special forecast of the Weather Bureau not been available, most of the growers would have waited until the 19th or 20th before making the application, when it was too late to protect the foliage.

During the past season the six assistants we had in the field traveled an aggregate of 34,343 miles, making 3,017 visits, and issued 66 circular letters with a total circulation of 18,207. It is very difficult to estimate the financial return to the growers of the counties concerned, but there is every reason to believe that the increased value of the crops directly resulting from the work would pay several times over the entire cost of the undertaking, including supervision and overhead.

THE COMMUNITY PLANT DOCTOR.

Your attention has been directed in the above quotation to our experience with industrial fellowship laboratories. The work of the field man on an industrial fellowship differs, in two respects at least, from that of the special field assistant. The former has for his primary function that of research or the solution by investigation of problems of pressing importance to the growers. He also performs the function of general advisor or supervisor on disease and pest control applicable to the crops grown by the farmers with whom he works. This, however, is a secondary though very important feature. In the second place his obligations are limited to a much smaller number of growers, usually from 12 to 25. He is the personal or local plant doctor for a very small number of growers, who provide his salary, living expenses while in the field, a laboratory room, and a car for his use in conducting the work. The college provides a complete laboratory equipment and directs his work. The fellow spends the growing season (four to six months) in the field, the remainder of the time at the college in study and investigation looking to his doctor's degree. The fellowship contract is so drawn that the growers may look forward to the services of the same man for a continuous period of from two to four years. The total cost to the growers per year ranges from \$1,500 to \$2,000. It costs the college an approximately equal amount to equip the laboratory and supervise the work.

During the period from 1909 to 1916, the department of plant pathology at Cornell University had about forty-five such annual fellowships, representing a total investment by our farmers and commercial concerns of some \$60,000. During the war, due to a lack of qualified men to fill such positions, the number of fellowships dropped to one, but last year we had three in operation and already requests for a total of eleven such arrangements for next season have been made. Two of these are from small groups of fruit growers. The others are distributed among groups of potato growers, cauliflower growers, market gardeners, truck growers and greenhouse men, and two have been provided by a commercial company for investigations on dusting. Even in the last case the eager co-opera-

tion of farmers is assured to the extent of providing laboratory facilities, orchards, labor and cars for transportation.

This method of solving the plant disease problems of the State has proved highly profitable to the growers. The actual profits in dollars and cents which we are able to show prove this, and the overwhelming demand for more fellowships from many sections of the State indicate the enthusiasm for and the confidence with which the hard headed farmers of New York are turning to scientific methods in solving their plant disease problems.

A MEMBER. I would like to know how you control bitter rot on apples.

Professor WHETZELL. Now, before I can answer that question, I must be sure I know what you are talking about. Bitter rot of apples, as the plant doctors know it, isn't a disease of New York and New England. It is a disease of the South. I do not believe you have bitter rot. There was bitter rot in the Hudson valley this year, but I think you mean a Baldwin spot, a little brown spot under the skin, with a depression over it. If you want to call it "bitter," call it bitter pit. If you call it bitter rot, the plant doctor thinks it a disease which occurs in the South. It cannot be controlled by spraying. To explain to you briefly, we think it happens this way: It is a very common disease the world over where apples are grown. It comes only in those seasons where we have had sudden changes from wet to dry some time during the season.

The explanation is this: Suppose you start off with a wet spring. You have a certain amount of root surface developed to feed a certain amount of foliage with water. If the weather suddenly becomes dry, there isn't enough root surface to get far enough to supply the top leaves and the fruit, and the result is either the leaves or the fruit suffers from lack of water.

It is well known that when it is a fight between fruit and leaves, the leaves get it. In other words, water is withdrawn from the fruit to go into the leaves, and you will notice that spot is always worse around the blossom end. It is around the blossom end that the tips of the sap tubes have their opening

to the outside. Naturally, those are farthest away from the water supply, so when the water begins to be pulled away from the current and there isn't water enough to supply the whole apple, the little tips of the sap tubes out around the blossom end and the cells which surround them, have no water.

You get all degrees of injuries, too, from cells that are dead to those more or less injured. You put those apples in storage and not having enough water in the apple, those cells, slightly injured cannot draw it, and they die; and it gets worse and worse until you have large numbers of those spots under the skin, running into the heart of the apple and turning brown, and it dies. That is the explanation given for bitter pit.

The only thing that can be done, as far as I know, is to make every effort to maintain a uniform water supply during the season. If you have a wet spring and dry weather follows, anything you can do in the way of cultivation to ease that drop from much water to a little water and to keep a high amount of water in the soil will tend to reduce the amount of Baldwin spots.

The fewer apples you have on the tree, the more injury there will be. I do not understand it well enough to explain, but that is the general theory. I have never myself carried on investigations on the thing, but there were extensive investigations recorded some few years ago on the disease in Australia, where the disease is bad. The evidence we collected year after year in the State of New York indicates that bitter pit, or Baldwin spot, is the result of sudden changes in the water supply during the season. We never have Baldwin spots in the State of New York when we have a uniformly wet season or uniformly dry season, because then the balance between root and leaf is not disturbed.

Chairman JENKS. A question is asked, is it worse with trees in sod than those in cultivated areas?

Professor WHETZELL. I have no data on that. My opinion would be it was likely to be, particularly if the sod pumps the water out. It tends to emphasize the change. It may or may not. It depends on the season, and depends on the conditions in your orchard. Probably in that orchard, if the grass was cut and used as a mulch, you might not get that effect.

A MEMBER. Why do you have a Baldwin spot in one tree and not in another tree?

Professor WHETZELL. The only way I can answer that is to ask why does one man get baldheaded and another man doesn't? There is some particular condition respecting that tree. Trees are just as individual as you fellows are. Some of them, because of the particular soil in which they grow, or conditions under which they grow, or their inherited tendencies, or something of that sort, show more Baldwin spots. Just as some of you fellows can wear your hat all the time and not get baldheaded. Others can't wear it at all. You will get baldheaded, anyway.

A MEMBER. I would like to ask Professor Whetzell if he thought he could control apple scab just as well by dusting as he could by the liquid spray. I have often found the liquid spray in the pink stage is just as important as the spray after the blossoms fall.

Professor WHETZELL. In New York State it is more important.

A MEMBER. How can you get dust on the pink stage?

Professor WHETZELL. Just as well as on the calyx.

A MEMBER. Is it as effective on the McIntosh where they are subject to apple scab?

Professor WHETZELL. Taking the averages of the experimental dusting work done in New York, Illinois, Michigan and Nova Scotia, taking the average of the work going on since 1912, — I do not know how many total years that would be for all of them, — but taking those averages, as I took them last week, I found on the average the difference between dusted and sprayed trees, so far as scab control was concerned, did not vary more than 3 or 4 per cent, which is within the range of experimental error. Now that you talk specifically on that particular variety, I do not recall the varieties that were involved, but I do recall that in a number of these cases we had as high as 95 per cent or more of scabby fruit on the checks, and reduced it to 85 to 90 per cent on the dusted. Does that answer the question?

A MEMBER. Do you advocate dusting under any conditions when the trees are in blossom?

Professor WHETZELL. No, it isn't necessary, any more than I would advocate spraying. Now, so far as injury to the fruit is concerned, there is no evidence that spraying or dusting when the trees are in blossom will injure the set of fruit. No evidence, no experimental evidence, as far as I know. The bee men are very certain it kills the bees if you spray or dust when the trees are in blossom. We have dusted trees experimentally in blossom, and we have sprayed trees experimentally in blossom. There is, as far as I know, no experimental evidence to show that spraying or dusting kills bees. I once went over the matter with a professor who made a very careful search for evidence on that point, and he said there was none. I do not say it doesn't kill bees. I do not know. But I say, as far as the experimental evidence goes, there is absolutely none to show it injures the bees and none to show it injures the set of fruit.

A MEMBER. That is the reason I asked that question. Formerly I used to make more than \$1,000 on bees. Last year I lost \$100. A man there locally will spray his trees many times. He knows better. There is no law against him. He sprays with a weak solution, and he claims it doesn't kill the bees, but the whole hive will dwindle down when the poison has been used in that way.

Professor WHETZELL. As far as I know, there is no carefully carried out experiment on that subject to prove it, one way or the other, but the point is, it isn't necessary to spray when the trees are in blossom. There is no particular point in doing it. There may be once in a good many years such weather conditions where it would be profitable to catch the trees when they are in blossom. In other words, the trees usually blossom during a rainless period. At least, the blossoms open when the sun shines. He should have it ahead of the rain. If a man sprays his trees properly with respect to weather, there is practically never any occasion to spray when they are in blossom; therefore, he and the bee man can live happily without arguing the question. They don't need to even discuss the question, because they don't have to spray when they are in blossom.

Chairman JENKS. The question is asked if you know of satisfactory means of controlling pear psylla.

Professor WHETZELL. That is out of my line. That is a bug question, and I wouldn't offer you any opinion on it.

Chairman JENKS. Can you tell us what is the general practice in New York, where they grow so many pears?

Professor WHETZELL. I never tell anything about bugs. I can't forget my line.

Chairman JENKS. The question is asked relative to dry lime-sulfur, and its merits.

Professor WHETZELL. We have carried on no investigations in the State of New York on the use of dry lime-sulfur. We had one or two demonstrations carried out by the Farm Bureau, and I think this is the general status at the present time in connection with the dry lime-sulfur. I am quoting Professor Parrott, who, while he is a bug man, has also launched into some of the things from the other side. As far as fungous diseases are concerned, if enough dry lime-sulfur is used in the solution, it will be just as effective as the liquid, because it is the same thing, but, as ordinarily sold and recommended, the dilution is too weak. I believe Professor Parrott said to our men last year that 23 to 25 pounds per 50 gallons should be used to give the same result you would get with 1 to 8, of commercial lime-sulfur liquid, or something of that sort, for scale. Then you diluted accordingly to get 1 to 40.

A MEMBER. Professor, do you expect that dusting would be as effective as spraying in a season when there is much wind? I mean particularly after the spray has been applied. Say you get up in the morning and get the dust on before the wind came. Would it be possible, if the leaves were dry, that the dust would be blown off?

Professor WHETZELL. I will answer you by an experience of your own. You drive a car? Yes? You wash it sometimes? No? Never wash it? Well, I can't help you. Well, you have seen fellows wash their car. Yes, nice and clean and shiny. Then they drive it through a dusty road, and then they come in and turn the hose on and soak it with water to wash it off, but the dust was still there when they got done. They had to take a rag and wipe it off. If you can't wash it off with a hose, it isn't likely any wind that blows in New England would blow it off. It doesn't blow off. The finely ground sulfur sticks

just the same as the same sulfur put on wet. It sticks like dust sticks to furniture or to the carpet, and it will stick just as well, as far as I know, as it will when it is put on wet. So, so far as blowing off is concerned, you do not need to worry about that, unless you have windier blows here than we have in New York State. The question is often raised whether it will wash off, and I give the same illustration.

Chairman JENKS. Can you give us some idea as to the relative costs of spray materials and labor in dust and liquid spraying?

Professor WHETZELL. There is no question but what dust materials to-day cost more money than the same materials for spraying, that is, than the spray materials that are used. But that is not the way to figure your relative costs of course. If you figure labor saved and time saved and the value of timeliness, — well, leave out that which is the most valuable point, — the time and labor saved, if you figure those in, counting labor costs and cost of materials, in Nova Scotia this year Professor Saunders found that to dust cost about the same as to spray. I think in the two experiments that he made his figures on, the difference was 10 cents less to dust than it was to spray, per acre, — a small amount.

Now, the relative costs of those methods would depend upon many factors which are not constant. A man who has everything right for spraying — water handy, doesn't take much time to fill, and good engines — can put his spray on cheaper than a man who has all these other troubles.

But taking it by and large this last year, so far as I have been able to get figures — accurate figures — experimentally taken by Professors Saunders and Brittain in Nova Scotia, those figures show that the cost, counting labor and materials, was approximately the same for the two.

Now, then, that was counting the relatively high cost of materials for dusting, but, as I pointed out to you, we are in the experimental stage with dusting, and naturally the stuff costs more money than when it is commercial, so you can save on the cost of apparatus. In other words, we are using a crude machine as compared with sprayers, and the duster will be improved. We will get around to it by and by until we control

the dust. We want to go over our methods and our arrangements, and I want to say that those who will do so will do a better job with less material wasted.

Now, another interesting thing. Professor Saunders developed a Bordeaux dust which promises to be as effective as liquid Bordeaux. He found that where he dusted with this Bordeaux dust on apples and compared with it spraying with Bordeaux, although he put 75 gallons of material on in spraying and only 50 pounds in dusting, that he actually got more copper on the leaf surface by dusting than he did by spraying.

In other words, the actual wastage of copper was less in the dusting than it was in the spraying, a thing nobody suspected. The chemist actually found a higher percentage of copper on dusted trees than he did on sprayed trees, so the actual wastage under present conditions in that orchard where he was using Bordeaux in both cases was less for dusting than for spraying.

Chairman JENKS. What is the smallest acreage you would suggest putting on the dust at its present stage of development?

Professor WHETZELL. I would leave that to the individual. I never recommend anything. That is one thing I want you to remember when you go away from here, — Whetzell did not recommend a single thing. I am trying to give you the facts as I have them and my opinion, which you can take for whatever it is worth, but if you go home and buy a duster and it doesn't work, don't look at me.

Chairman JENKS. What do you think of soluble oil as compared with lime-sulfur?

Professor WHETZELL. In the first place, soluble oils are used primarily to control insects, scale, and so forth. They are not used as fungicides to any extent. I have no information on it. I have carried on no experiments, and I do not know. The only thing I can imagine soluble oils used for in a fungicide is disinfecting peach trees for curl.

Chairman JENKS. The question is asked how about the sooty blotch on apples?

Professor WHETZELL. It can be controlled by any of the spray mixtures you use. You have got to put on a later

application. That means ordinary apple scab sprays won't catch.

Chairman JENKS. Sooty blotch is very bad with us in eastern Massachusetts.

Professor WHETZELL. Sooty blotch is a disease that comes on relatively late, and you have got to get a mixture on ahead of it, and probably a couple of them.

Chairman JENKS. The question is asked, why is it better to spray before rather than after rain?

Professor WHETZELL. Well, for exactly the same reason that it is better to get inoculated for typhoid before you get it than after.

Here is the situation. Take the apple scab. The first infections in the spring are produced in the old leaves of last season that lay on the ground, the scabby foliage of last year, that fell to the ground this year.

Those spores are shot from the old leaves, and then a breeze catches them and carries them to the foliage, but they are only shot out during rains, and they get on to the leaves only during rains, and they germinate, and they go into the leaves during that rainy period.

In other words, to get apple scab infection on your early foliage, you have to have about forty-eight hours of rainy weather, some rain for a period of about forty-eight hours, and you will get infection. The fungus will be inside the leaf. If you have no protection on the foliage, you can go if you want, after the rain is over, and put it on the outside, but the spray mixture does not operate to kill the fungus.

In other words, spraying is a protection.

Now, some of you labor under the delusion that you spray to kill something which is already there. You do not. You put the spray mixture on to protect it from something that is going to come, and that something comes during the rain. Almost all fungi are either put on the leaf in the rain or germinate only during a period when the surface is wet; therefore, you must put protection on ahead and not after.

Any other question?

Chairman JENKS. Is it the opinion, Professor, that it is

almost impossible to do as cheap a job with a spray gun as it is with a spray tower and two rods?

Professor WHETZELL. No, it is possible to do as good a job with the spray gun, in my opinion, but it ordinarily isn't done that way, for the reasons I pointed out. If you have a man on the ground and another one on the tower, on a 10 or 15 foot tower, with a good angle nozzle on the end, you apply so much spray per second, and you cover all parts of the tree, and you do not drench any part of it. If a man is out on the tower with a spray gun, and another man on the ground with a spray gun, and the trees were not so large but what you could shoot this mist into the middle of the tree, you can do just as good a job, and applying so much more mixture per second you have to be on the job constantly. That is what happens. The hired man turns on the gun, and the more stuff he can get out of it, the better it looks to him, and he drenches the trees in spots. I saw an orchard in Nova Scotia sprayed with a spray gun where the fellow shot the tree; he took all the leaves and apples off.

Chairman JENKS. If you were doing the job yourself, and of course wanted to save time and expense, would you be inclined to use the gun or the rod?

Professor WHETZELL. I never had any extensive experience with the gun on my own account, but my own opinion is that I would stick to the pole and get a big angle nozzle on the end of it. I think I would save enough material and do enough better job to warrant me using the pole and nozzle than I would with a spray gun. I have seen some men spraying with a spray gun, especially if the trees were small, and they were up on the wagon, do a pretty good job with it, but I have seen many more men, who opened it wide to get to the top of the tree, do a poor job on the top and drench the trees below. So that in the hands of the ordinary man, the average man, I believe that better work will be done with a pole and nozzle than with a spray gun. That is not saying you can't do good work with a gun.

Chairman JENKS. It is particularly applicable to high trees?

Professor WHETZELL. Particularly so, yes, sir, and particularly applicable to the man who isn't very much interested in

doing it exactly right. You see, you are shooting so much more stuff at a time, your chances of doing damage are much more than where you have a small amount.

Chairman JENKS. I think, friends, we will have to draw this discussion to a close, as the time is gone. I am sure that even though Professor Whetzell did not recommend anything to us, he gave us a whole lot to think about that we will try to put into practice somewhat on our own farms this year.

